Report DARCOM-ITC-02-08-76-206

INVESTIGATION OF THE EFFECTIVENESS OF GUN TUBE CLEANERS CURRENTLY USED IN THE FIELD

Geoffrey N. Marshall
Product/Production Graduate Engineering Program
DARCOM Intern Training Center
Red River Army Depot
Texarkana, Texas 75501

May 1976

Final Report

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

Prepared for

PRODUCT/PRODUCTION GRADUATE ENGINEERING PROGRAM
AND TEXAS A&M UNIVERSITY GRADUATE CENTER
DARCOM Intern Training Center - USALMC
Red River Army Depot
Texarkana, Texas 75501

FOREWORD

The research discussed in this report was accomplished as part of the Product/Production Engineering Graduate Program conducted jointly by DARCOM Intern Training Center and Texas A&M University. As such, the ideas, concepts and results herein presented are those of the author and do not necessarily reflect approval or acceptance by the Department of the Army.

This report has been reviewed and is approved for release. For further information on this project contact: Professor T. F. Howie, DRXMC-ITC-PPE, Red River Army Depot, Texarkana, Texas 75501.

Approved:

T. F. Howie

Professor T. F. HOWIE, P.E.
Chairman, Department of Product/Production Engineering

For the Commandant

James L. Arnett

JAMES L. ARNETT, Director
DARCOM Intern Training Center

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER DARCOM-ITC-02-08-76-206	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Investigation of the Effectiveness of Gun Tube Cleaners Currently used in the Field		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Geoffrey N. Marshall		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Product/Production Graduate Engineering Program DARCOM Intern Training Center Red River Army Depot, Texarkana, Texas 75501		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Product/Production Graduate Engineering Program & Texas A&M University Graduate Center DARCOM Intern Training Center - USALMC		12. REPORT DATE March 1976
		13. NUMBER OF PAGES 31
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Approved for Public Release: Distribution Unlimited

18. SUPPLEMENTARY NOTES

Research performed by Geoffrey N. Marshall under the supervision of Dr. R. S. Morris, Industrial Engineering Dept., Texas A&M University

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Gun Tube Cleaners
Cannon Bore Cleaners
Rifle Bore Cleaner

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report compares the accepted rifle bore cleaning compound against several known substitutes namely preservative lubricant, hydraulic fluid, diesel fuel and dry cleaning solvent. An experiment was performed in which corrosion was the critical factor. The results indicated rifle bore cleaning compound is the only acceptable cleaner.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

ABSTRACT

Research Performed by Geoffrey N. Marshall

Under the Supervision of Dr. R. S. Morris

The purpose of this report is to determine the effectiveness of gun tube cleaners currently being used by the United States military forces in the field. Rifle bore cleaner, which is the recommended cleaner, was compared to preservative lubricant, hydraulic fluid, diesel fuel and dry cleaning solvent. To facillitate this comparison a single factor completely randomized experiment was performed. The acceptance test for rifle bore cleaner (MIL-C-372 B) was used to evaluate the cleaners and an analysis of variance was completed on the data obtained from the experiment. From the test results it was determined that all of the cleaners performed significantly worse than the recommended rifle bore cleaner.

ACKNOWLEGEMENTS

I extend my appreciation to Dr. R. S. Morris for serving as the chairman of my committee and providing technical assistance in preparing this report. Mr. P. Duvall was instrumental in coordinating the experimental work done through Rock Island Arsenal. I also thank Dr. J. Covan and Dr. Bart Childs for serving on my committee and reviewing my report.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

In a recent report by Army field maintenance experts (included as Appendix A) it was stated that several unauthorized gun tube cleaners are being used. Army maintenance manuals state that Rifle Bore Cleaning Compound (MIL-C-372B) shall be used to clean the gun tubes immediately after firing and at prescribed intervals as part of standard maintenance procedure. In actual practice, however, hydraulic fluid, diesel fuel, dry cleaning solvent and preservative oil are being substituted as gun tube cleaners. These fluids serve a multitude of functions in field operations and thus are readily available and kept in good supply. Rifle Bore Cleaner (RBC), on the other hand, has a unique function and must be specially ordered. Procurement is often neglected or else gun crews simply don't bother to retrieve the RBC from storage. Consequently there is a significant use of unauthorized cleaners.

The possibility of a cost reduction as well as concern for gun tube life were motivating factors in conducting this study. If any of the substitute cleaners performed as well as the RBC then a study of procurement, storage, and handling costs could determine the cheapest alternative. If, on the

other hand, RBC is found to be the only effective substance, the Army should exercise tighter control over its use in the field.

To determine the relative effectiveness of the cleaners, an experiment was conducted. This experiment is a duplication of the acceptance test currently used for RBC. RBC was used as the control to which other cleaners (hydraulic fluid, diesel fuel, dry cleaning solvent and preservative oil) were compared. A specimen which had no treatment was also subjected to the same experimental procedure to obtain an absolute scale of comparison. The facilities for testing RBC are located in the chemical laboratory at Rock Island Arsenal, therefore, this site was chosen for the experiment.

CHAPTER II

BACKGROUND

Two mechanisms are responsible for barrel wear. One is erosion or the abrasive removal of metal from the bore lining and the other is corrosion, the chemical oxidation of steel. Erosion can be controlled through the amount of friction occuring between the projectile and the walls of the gun tube. A study by B. Broadman and M. Devine [2]* revealed that the amount of erosion can be controlled somewhat by substances such as talc, which are added to the gunpowder. This talc remains in the barrel as part of the gunpowder residue and serves as a lubricant when several rounds are fired in succession without cleaning. During short intervals between firing (i.e. several hours) corrosion does not significantly increase gun tube wear. If, however, the corrosive primer salts remain on the bore lining for periods longer than a day, they absorb moisture from the atmosphere forming acids which rapidly oxidize the steel bore lining. For this reason the removal of corrosive agents becomes critical to the life of the gun tube.

---

* Numbers in brackets refer to numbered references in the List of References.

At the present time Army maintenance manuals, such as the lubrication order for the tank mounted 105 MM gun [10], specify the cleaning procedure for the cannon bore, breech, and operating mechanism as follows:

> Immediately after firing and on two consecutive days thereafter, thoroughly clean with Rifle Bore Cleaning Compound, insuring that all surfaces (including rifling) are well coated. Do not wipe dry. On the third day after firing, clean with Rifle Bore Cleaning Compound, wipe dry and lightly coat with preservative oil, (PL). Quarterly thereafter, or as required, when cannon is not being fired, clean with Rifle Bore Cleaning Compound, wipe dry and reoil with PL.

The possibility of altering this cleaning cycle was investigated by D. Bootzin[1]. His study dealt with the possibility of reducing the cleaning period from three days to one. Other questions answered by the study were: "How effective is the rifle bore cleaner used in removing powder residue, primer salts, etc.? To what extent do stain and corrosion affect the serviceability of the tube? What criteria is employed to determine when a cannon tube or breech is clean?" To answer these questions he conducted a test on three 155 MM and three 105 MM howitzers. One howitzer in each group was given a one day cleaning and the third from each group was given the standard three day cleaning as described above. The rifle bore cleaner used was tested at Rock Island Arsenal for conformance to military specification MIL-C-372. As a result of the test it was found: "RBC is designed to remove corrosive primer salts by means of slushing a part in

the fluid. When used generously the cleaner functions as intended. However, there is no assurance that recesses, fissures, pits, etc. will be flushed out sufficiently unless the operator takes special pains to clean easily missed areas." In answer to the question on how stain and corrosion affect the serviceability of the tube, he states: "Guns fired and not cleaned rusted badly. If allowed to continue, parts in the breech would freeze, the chamber would become rougher as the corrosion would eat at the metal. A point of deterioration would be reached where the dimensional tolerance would be exceeded with resulting loss in the accuracy." Corrosion also became evident after a week on the guns receiving a one day cleaning whereas the guns given the standard treatment were rust free. Therefore the study deemed it unwise to reduce the cleaning period. Bootzin determined the criteria for a clean tube as that which yielded light streaks but not dark stains on a dry swab pushed forcefully through the tube. Complete cleanliness could be achieved by many repeated cleanings but this was not found necessary nor practical.

In light of this study the cleaning procedure can be eliminated as a variable which leaves only the cleaner itself to be investigated. Rifle bore cleaner has proven effective in laboratory tests, the study of Bootzin, and years of use by the Armed Services. What remains to be seen is whether some of the other petroleum products used in the

field can be used as gun cleaners thus reducing inventory cost and possibly eliminating shortages.

Removal of primer salt residues and the formation of a protective film are critical to the protection of bore linings from corrosion. Bootzin stated in his report that certain areas of the gun tubes are not cleaned well such as along the rifling and in any pits or fissures. This fact, in conjunction with the impracticality of removing all stains completely, makes it necessary for an effective cleaner not only to have good detergent characteristics but also it must dissolve and neutralize any corrosive residue left behind by the cleaning process. RBC is a suspension of water in oil which will dissolve primer salts and then displace the salt and water mixture leaving the oil in contact with the metal. The corrosion protective requirement for RBC is stated in Military Specification MIL-C-372B [3]:

> 3.8.1. Performance (primer salts removal). The cleaner shall remove primer salts and prevent rusting.
>
> 3.8.2. Humidity Cabinet. The cleaner shall be capable of protecting parts against corrosion during continuous condensation on parts at temperatures up to 120°F.

RBC currently used in the field has been tested by Rock Island Arsenal and found to meet both requirements (testing procedure described in Appendix B). What remains to be determined is whether lubricating oil, hydraulic fluid, dry cleaning fluid and diesel fuel can also meet these requirements.

Since preservative oil (PL) is currently used to protect the bore lining after it has been cleaned with RBC, its preservative qualities are not in question. The effectiveness of PL as a cleaner, however, has not been determined. The Military Specification for PL (MIL-L-3150B) [8] states under corrosion protection:

> 3.4.1. Humidity Cabinet. Three steel plates treated with PL shall be exposed to a humidity cabinet atmosphere for 240 hours. Not more than three corrosion dots (total), none of which exceeds one millimeter in length, width, or diameter shall be evident on the test panels.
>
> 3.4.2. Salt-spray resistance. Three oil treated panels subjected to a salt spray for 48 hours shall not have more than three corrosion dots apiece and nine altogether.

The humidity cabinet test for both the RBC and PL are nearly identical; however, the salt spray test only assures protection of surfaces which were coated with PL before introducing the salt spray and does not assure the removal of previously deposited primer salts.

Hydraulic fluid also has preservatives according to a lubrication publication by Texaco [9]. Oxidation inhibitors are added to retard the oxidative decomposition of the oil and to passivate the metal surfaces. Rust inhibitors form a film on the surface of the metal which repels water and neutralizes acid. This prevents rusting of ferrous parts during storage and from acidic moisture accumulation. Corrosive inhibitors also form a barrier on the metal surface to neutralize corrosive contaminants in the oil and prevent them from attacking the metal. The Military Specification

for hydraulic fluid (MIL-H-6083D) [7] calls for a petroleum base oil with additive materials to inhibit corrosion and improve resistance to oxidation.

> 3.5.2.1 Corrosiveness. The change in weight of steel subjected to the action of the hydraulic fluid for 168 hours at 250°F shall be not greater than ± 1/2 milligram per square centimeter of surface. There shall be no pitting, etching, nor visible corrosion on the surface of the metal when viewed under magnification of 20 diameters.

> 3.5.4.4.6.3 Corrosion Inhibitors. Prepare six test panels, three polished and three sandblasted. After treating with hydraulic fluid, subject the panels to 120°F at 95 to 100 percent relative humidity. The test panels shall be free from corrosion.

The hydraulic fluid also affords protection against corrosion under long exposure to heat and humidity but is not intended to dissolve and remove primer salts.

Dry cleaning solvent (Federal Specification P-D-680) [5] must be non-acidic with a maximum sulfuric acid absorbtion of 5%. However, it is not tested for corrosion prevention on ferrous materials and no anti-corrosion additives are specified. This leaves both properties of corrosion prevention and primer salt removal in question.

Diesel fuel also is not intended as a preservative for ferrous metals but according to an SAE information report on diesel fuels [4], rust preventatives and oxidation inhibitors are sometimes used as additives. This may offer protection for short periods of time but long term protection is in question.

As a means of determining which of the cleaners possessed the critical cleaning and preservative properties, two sections of the

acceptance test for RBC were chosen. The test procedure is listed in detail in Appendix B and summarized in Chapter III.

CHAPTER III

EXPERIMENTAL DESIGN

Materials

A total of 66 steel plates 2 by 4 by 1/8 inch were used in the tests. Half (33) were used in the performance test and the other half used in the humidity cabinet test. Each of the two tests were subdivided into 6 groups corresponding to the 6 treatments as follows:

1) 3 steel specimens receiving no treatment.
2) 6 specimens treated with RBC.
3) 6 specimens treated with PL.
4) 6 specimens treated with hydraulic fluid.
5) 6 specimens treated with dry cleaning solvent.
6) 6 specimens treated with diesel fluid.

Purpose

The tests were conducted to determine if PL, hydraulic fluid, dry cleaning solvent, and diesel fuel performed as well as RBC when subjected to the bore cleaner acceptance tests. To provide an absolute scale of comparison, untreated specimens were included in the experiment. The acceptance test, as outlined in MIL-C-372B, consists of two parts. 1) The performance test indicates the ability of a cleaner to remove primer salts and, 2) the humidity cabinet test assures the preservative ability under long exposure to humid conditions.

The petroleum products were obtained at Red River Army Depot, Texarkana, Texas. The one gallon samples of each product were taken randomly from unused supplies. All other materials and test equipment were supplied by the test laboratories at Rock Island Arsenal, Rock Island, Illinois.

Procedure

The following test procedure is condensed from MIL-C-372B as listed in Appendix B.

4.11 Corrosion Protection.

4.11.1 Performance (primer salts removal).

4.11.1.1 Test panels. The test panels shall be 2 by 4 by 1/8 inch; low carbon, cold-rolled 1020 steel.

4.11.1.2 Cleaning test panels. The test surfaces of the panels shall be cleaned with naptha and methanol and stored in a dessicant until further processing.

4.11.1.3 Sandblasting test panels. The numbered side of the test panels shall be sandblasted to a fresh uniformly abraided surface. The panels shall then be cleaned in methanol and naptha and used the same day as prepared.

4.11.1.4 Test procedure. The test panels shall have a Cal. 30 primed, (corrosive) empty cartridge case fired at the center of each. The panels shall then be slushed in approximately 800 ml. of the cleaner under test for 2 minutes. The panels shall then be exposed in the humidity cabinet specified in Specification JAN-H-792 for 3 days. Following this the panels shall be examined in the significant area of the panels as defined in Specification JAN-H-792. The number of corrosion dots on each panel will be counted and recorded.

4.11.2 Humidity cabinet.

4.11.2.1 Test panels. The test panels for the humidity cabinet test shall be of the same size and material as specified in 4.11.1.1 and cleaned and sandblasted as specified in 4.11.1.2 and 4.11.1.3

4.11.2.2 Test procedure. The test panels shall be dipped in the test cleaner and agitated gently for one minute. The panels shall then be suspended and drained for two hours. The panels shall be subjected to 7 days of the humidity cabinet test specified in Specification JAN-H-792. At the end of the seventh day exposure period, the panels shall be removed, decoated with naptha and examined. The number of corrosion dots on each of the panels shall be counted and recorded.

CHAPTER IV

RESULTS

The number of corrosion dots found on each of the test panels is listed in Table 1 for the performance test and Table 3 for the humidity cabinet test. Since the single factor tests were conducted in a completely randomized manner, one-way analyses of variance were performed as shown in Tables 2 and 4.

The first test was to determine whether there was a significant difference in the average corrosion between the three treatments. The hypothesis was that the treatment means were equivalent and an F statistic was used to test the hypothesis at the 95% significance level. For the performance test (Table 2) and the humidity cabinet test (Table 4) the F statistics were shown to be significant and thus the hypothesis was rejected in each case.

The second test compared the means of each of the treatments against the mean of RBC. The method used in this test was to establish pairwise contrasts. Since there were two degrees of freedom between treatment means, two such contrasts could be made. Hypothesis number one (H_1) was that the average corrosion for the RBC treatment was equal to the average corrosion for PL. H_2 compared RBC to hydraulic fluid. Again these hypothesis were tested at the 95% significance level using an F statistic. For both the performance and humidity cabinet test, H_1 and H_2 were rejected.

Representative samples were chosen from each of the test results and photographed to provide a visual comparison. Figure I shows the results of the humidity cabinet test. The control, dry cleaning solvent and diesel fuel specimens all exhibit 100% corrosion with the dark spots indicating points of moisture accumulation. The dark spots and small grey areas on the panel treated with hydraulic fluid indicate significant points of corrosion scattered over the surface. The same indications of rust are apparent on the panel coated with preservative oil but are not as numerous. The bore cleaner panel remains relatively free of dots and spots.

Figure 2 is a photograph of representative panels taken from the performance test results. On all the panels the blast area is evidenced by the darker spots in the center. The control, dry cleaning solvent and diesel fuel panels again show 100% rusting but with a deeper corrosion obvious in the blast area. The hydraulic fluid panel exhibits more corrosion than the preservative oil and in both cases the corrosion is concentrated in the blast area. No dots or spots are evident on the bore cleaner panel.

TABLE 1 PERFORMANCE TEST - DATA*

Specimen #	RBC	PL	Hyd. Fluid	
1	0	22	64	
2	1	30	48	
3	1	46	30	
4	0	50	55	
5	0	34	34	
6	2	26	32	
$T._j$ (Totals)	$T._1=4$	$T._2=208$	$T._3=263$	$T..=475$

Sum of Squares

$$SS_{Total} = \sum_{ij} Y_{ij}^2 - \frac{T..^2}{an^{**}}$$

$$= 20343 - \frac{(475)^2}{(3)(6)} = 7808.278$$

$$SS_{Treatment} = \sum_{j} \frac{T._j^2}{n} - \frac{T..^2}{an}$$

$$= \frac{(4)^2 + (208)^2 + (263)^2}{6} - \frac{(475)^2}{(3)(6)} = 6206.778$$

$$SS_{Error} = SS_{Total} = SS_{Treatment}$$

$$= 7808.278 - 6206.778 = 1601.5$$

* notation and equations obtained from reference [6]

** a - number of treatments

n - number of specimens

TABLE 2 PERFORMANCE TEST - ANALYSIS OF VARIANCE

<u>One - Way ANOVA</u>

Source	d.f.	S.S.	M.S.
Between Treatments	2	6206.778	3103.389
Within Treatments or Error	15	1601.5	106.767
Totals	17	7808.278	

Test 1 H_o: Treatment means are equivalent

$$F_{statistic} = \frac{MS_{treatment}}{MS_{error}} = \frac{3103.389}{106.767} = 29.067$$

$$F^{.95*}_{2,15} = 3.68$$

$$29.067 > 3.68 \quad \therefore \text{Reject } H_o$$

Test 2 Pairwise Contrasts (C_m)

$$C_1 = T._1 - T._2 = 4 - 208 = -204$$

$$C_2 = T._1 - T._3 = 4 - 263 = -259$$

$$SSc_1 = \frac{C_1^2}{n \sum_{j=1}^{2} c_{j1}^2} = \frac{(-204)^2}{6\,[(1)^2+(-1)^2]} = 3468$$

$$MSc_1 = \frac{SSc_1}{d.f.=1}$$

* $F^{1-\alpha}$ - value from table of F distribution [6]
** C_{jm} - coefficients for T_{ij}

$$SSc_2 = \frac{C_2^{\,2}}{n^2 \sum_{j=1}^{2} c_{j2}^2} = \frac{(-259)^2}{6\,[(1)^2+(-1)^2]} = 5590.083$$

$$MSc_2 = \frac{SSc_2}{d.f.=1}$$

H_1: Treatment mean for RBC is equivalent to PL

$$F_{statistic} = \frac{MSc_1}{MS_{error}} = \frac{3468}{106.767} = 32.482$$

H_2: Treatment mean for RBC is equivalent to Hyd. Fluid

$$F_{statistic} = \frac{MSc_2}{MS_{error}} = \frac{5590.083}{106.767} = 52.358$$

$$F^{.95}_{1,15} = 4.54$$

32.482 > 4.54 $\therefore$ Reject H_1

52.358 > 4.54 $\therefore$ Reject H_2

TABLE 3 HUMIDITY CABINET TEST - DATA

Specimen #	RBC	PL	Hyd. Fluid	
1	0	16	86	
2	0	26	80	
3	16	34	74	
4	1	24	34	
5	4	30	30	
6	0	22	64	
$T._j$ (Totals)	21	152	368	$T..=541$

<u>Sum of Squares</u>

$$SS_{Total} = \sum_{ij} Y_{ij}^2 - \frac{T..^2}{an^*}$$

$$= 29745 - \frac{(541)^2}{(3)(6)} = 13484.945$$

$$SS_{Treatment} = \sum_{j} \frac{T._j^2}{n} - \frac{T..^2}{an}$$

$$= \frac{(21)^2+(152)^2+(368)^2}{6} - \frac{(541)^2}{(3)(6)} = 10234.778$$

$$SS_{Error} = SS_{Total} - SS_{Treatment}$$

$$= 13484.945 - 10234.778 = 3250.167$$

$$MS = \frac{SS}{\text{degrees of freedom}}$$

* a - number of treatments
n - number of specimens

TABLE 4 HUMIDITY CABINET TEST - ANALYSIS OF VARIANCE

One - Way ANOVA

Source	d.f.	S.S.	M.S.
Between Treatments	2	10234.778	5117.389
Within Treatments or Error	15	3250.167	216.678
Totals	17	13484.845	

Test 1 H_o: Treatment means are equivalent

$$F_{statistic} = \frac{MS_{treatment}}{MS_{error}} = \frac{5117.389}{216.678} = 23.617$$

$$F^{.95*}_{2,15} = 3.68$$

$$23.617 > 3.68 \qquad \therefore \text{Reject Ho}$$

Test 2 Pairwise Contrasts (C_m)

$$C_1 = T._1 - T._2 = 21 - 152 = -131$$

$$C_2 = T._1 - T._3 = 21 - 368 = -347$$

$$SSc_1 = \frac{C_1^{\,2}}{n \sum_{j=1}^{2} c_{j1}^{**}} = \frac{(-131)^2}{6[(1)^2+(-1)^2]} = 1430.083$$

$$MSc_1 = \frac{SS_{c1}}{d.f.=1}$$

* $F^{1-\alpha}$ - value from table of F distribution [6]

** C_{jm} - coefficients for T_{ij}

$$SSc_2 = \frac{C_2^{\,2}}{n\sum_{j=1}^{2} c_{j2}} = \frac{(-347)^2}{6[(1)^2+(-1)^2]} = 10034.083$$

$$MSc_2 = \frac{SSc_2}{d.f.=1}$$

H_1: Treatment for RBC is equivalent to PL

$$F_{statistic} = \frac{MSc_1}{MS_{error}} = \frac{1430.083}{216.678} = 6.600$$

H_2: Treatment for RBC is equivalent to Hyd. Fluid ($T_1=T_3$)

$$F_{statistic} = \frac{MSc_2}{MS_{error}} = \frac{10034.083}{216.678} = 46.309$$

$$F^{.95}_{1,15} = 4.54$$

$6.600 > 4.54$ ∴ Reject H_1

$46.309 > 4.54$ ∴ Reject H_2

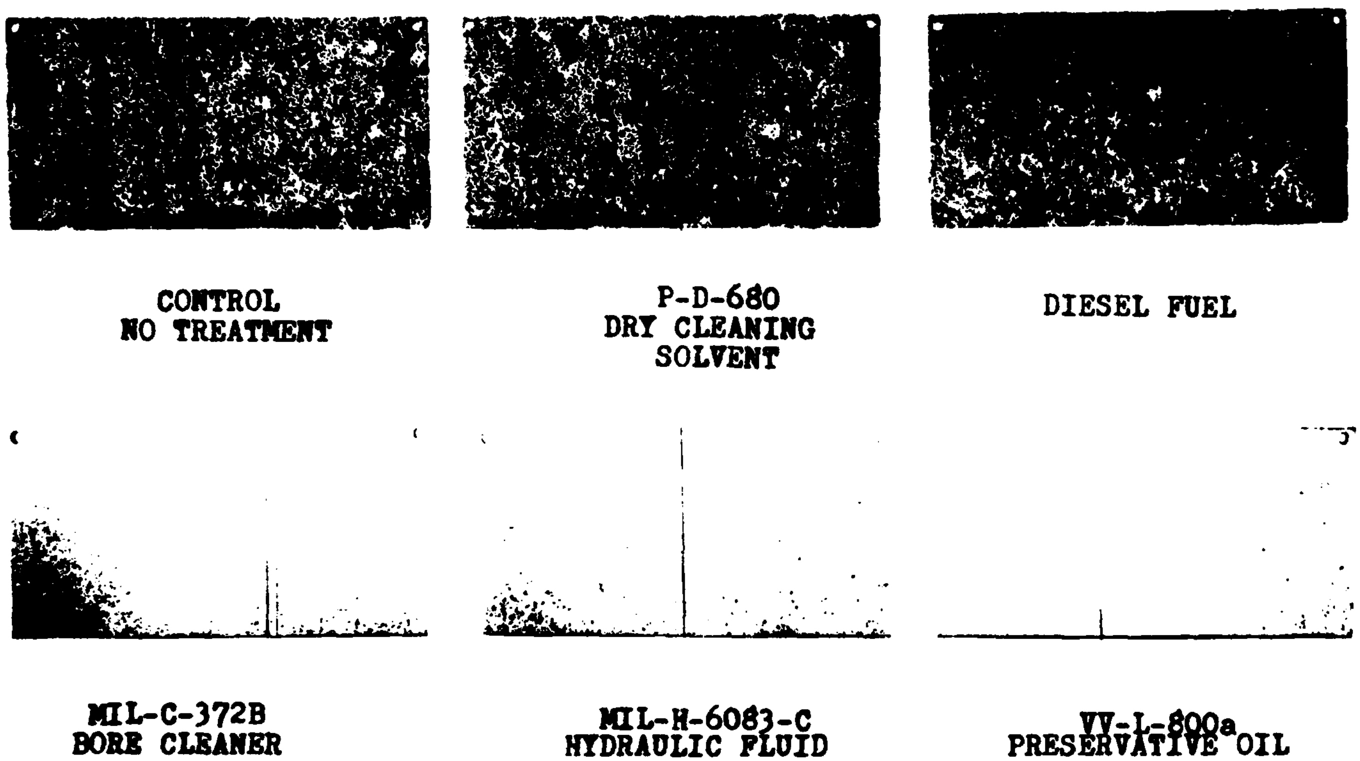

FIGURE 1

HUMIDITY CABINET TEST RESULTS.
11-199-5371/AMC-75

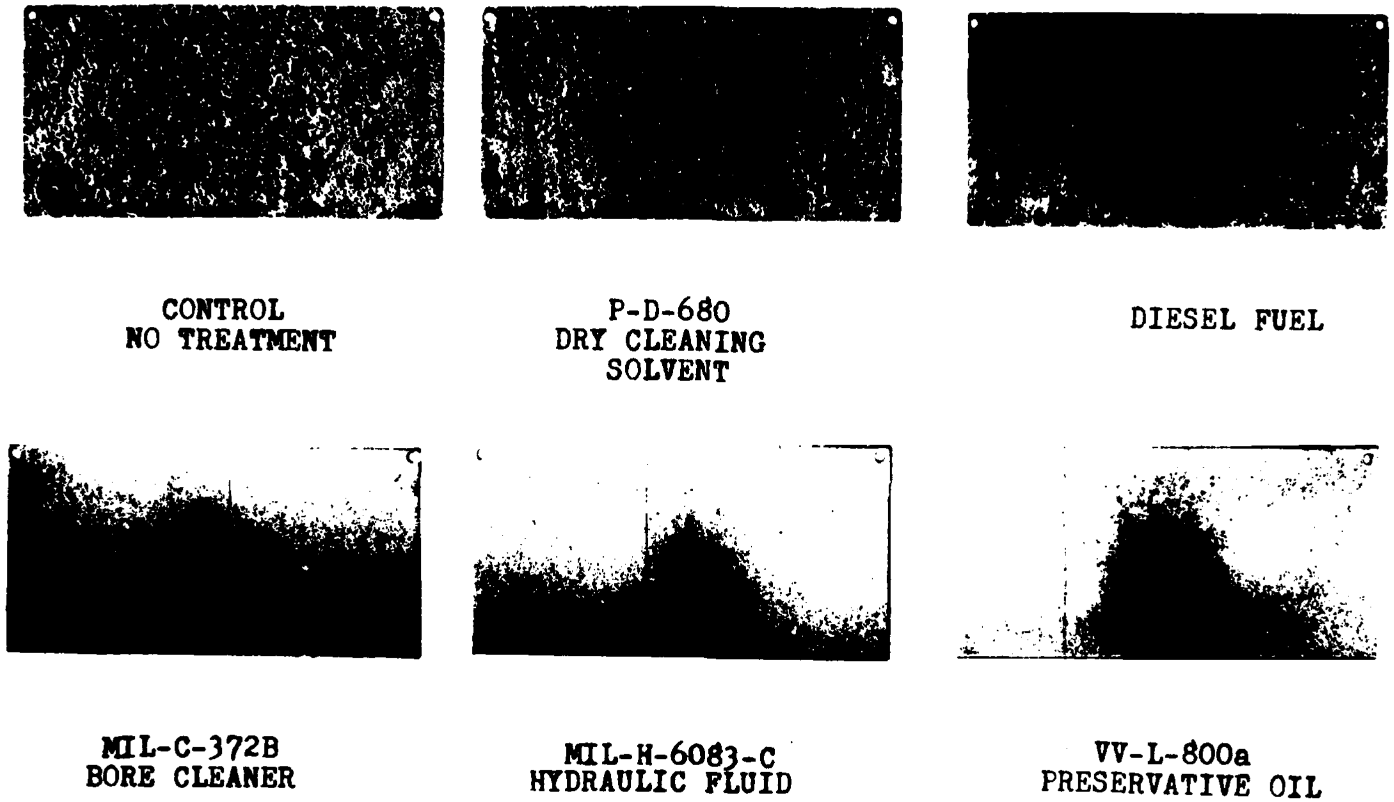

FIGURE 2

PERFORMANCE TEST RESULTS.
11-199-5370/AMC-75

CHAPTER V

CONCLUSIONS

Performance Test

The test panels which received no treatment experienced 100% rusting as expected. The blast area of the panel had deeper and more extensive corrosion and could be easily distinguished by its dark (almost black) color. This indicated that the primer salts will induce extensive corrosion when not treated or removed.

All specimens treated with diesel fuel and dry cleaning solvent were rusted to the same extent as the untreated panels. This indicates that diesel fuel and dry cleaning solvent were totally ineffective in removing primer salts and preventing corrosion.

In contrast, specimens treated with RBC exhibited an average of .66 corrosion dots per specimen. These were randomly located with no visible correlation to the blast area. The RBC thus passed the acceptance criteria for performance in removing primer salts (maximum average of 1 corrosion dot per panel).

PL had an average of 34.66 corrosion dots per panel and hydraulic fluid had an average of 43.83. In both cases the corrosion dots were scattered over the entire specimen but there was a noticeable concentration of dots in the blast area. From the analysis of variance it was determined with 95% confidence that the means of the treatments were not equivalent. Also when compared individually to the RBC the means were found to deviate significantly. From these results it

can be concluded that although PL and hydraulic fluid performed much better than no treatment, diesel fuel or dry cleaning solvent; they did not completely remove the primer salts and thus are not acceptable per MIL-C-372B.

Humidity Cabinet Test

Specimens without treatment and those treated with diesel fuel or dry cleaning solvent all exhibited 100% rust after seven days in the humidity cabinet thus indicating a complete lack of preservative qualities.

Panels coated with RBC had an average of 3.5 corrosion dots per panel which exceeds the required maximum average of one but is still minimal compared to an average of 25.33 for PL and 61.33 for hydraulic fluid.

PL should have tested as well as the RBC since the acceptance test for PL calls for 192 hours in the humidity cabinet with a maximum average of 1 corrosion dot per panel. The fact that PL failed for this criteria could be attributed to a contaminated fluid sample or, since only one sample of fluid was drawn, a deviation from the expected quality is possible. Routine testing on PL has not indicated any problems in overall quality. The analysis of variance again indicated no similarity between population means of the treatments taken as a group and individually in comparison to RBC. It can be said with 95% confidence that the PL and hydraulic fluid did not perform as well as the RBC.

Recommendations

The test results clearly indicate that none of the substitute bore cleaners perform as well as the RBC. In this light it is recommended that RBC be used exclusively in the cleaning of cannon bores. If for some reason a substitute must be used; of the fluids tested, PL comes closest to RBC in test results. Hydraulic fluid is the second recommended alternative.

APPENDIX A

SARFS LOGISTICAL ASSISTANCE REPORT

To AMSAR - MAW - T From SARFS 14 February 1975

Mr. Ebersole

1. Inquiry was made to your request for the following information.

2. Step by step procedure used in cleaning of gun tube, as follows.

A. Open breech.
B. Assemble staffs 1090-563-7239 and insert staff into muzzle end of tube running staff end thru tube to extend beyond breech chamber far enough to assemble bore brush to end of a staff.
C. Assemble bore brush 1025-189-5762 to end of staff and saturate brush with Compound Rifle Bore Cleaning 6850-224-6663 or Dry Cleaning Solvent 6850-281-1985, or perhaps Diesel Fuel, also if Hydraulic Fluid is a little handier you may see some 1950-935-9808 go into action. Brush is usually saturated by dipping or pouring one of the above fluids on it and pulling it through tube to muzzel end. This method is repeated until tube is clean.
D. Tube is wiped dry and coated with oil engine 9150-265-9425 or lubricating oil general purpose 9150-231-6689 and sometimes GAA 9150-190-0905.
E. Tubes are usually cleaned three consecutive days after firing, and coated with some kind of oil. Tubes are usually cleaned once a week unless they are coated with GAA.

3. The above method is used in the ACR Area of which I have had experience with. Also I observed tubes being cleaned in this manner during the week of 3 thru 7 February. Bore cleaner is available in all Areas and people just don't use it. The same goes for all other cleaning and lubricating materials.

4. Bore cleaner is not distributed in tube prior to using bore brush.

5. Bore cleaner, Solvent, Oils, etc. are listed in the "B" Section of TM 9-2350-230-12 with Stock Numbers and Military Specifications. This is the using Units authority for ordering and maintaining their supplies.

It is realized that this method is not in accordance with the TM, but is has been stated the way they do it.

Edward B. Ebersole
ARMCOM FMT
HHD 71 Maint. Bn
APO NY 09696

Copy Furnished LAO-E
LTC Anderson.

APPENDIX B

TEST PROCEDURE (FROM MIL-C-372B)

4.11 Corrosion protection.

4.11.1 Performance (primer salts removal).

4.11.1.1 Test panels. The test panels shall be 2 by 4 by 1/8 inch; low carbon, cold-rolled 1020 steel conforming to Specification QQ-S-640. Badly rusted stock shall not be used for making test panels. The edges of the panels shall be rounded and suspension holes reamed in accordance with Specification JAN-H-792, prior to cleaning.

4.11.1.2 Cleaning test panels. The test surfaces of the panels shall be cleaned with naptha conforming to Specification TT-N-95, and methanol conforming to Specification O-M-232, Grade A, as follows:

(a) While cleaning the test panels they shall be handled with hooks or forceps at all times. All precautions shall be taken to guard against impurities on the test panels by avoiding contact with any type of contaminated surfaces. The utensils and solvents used must be cleaned and free from contamination.

(b) The solvents shall be maintained at a temperature high enough to keep the temperature of the panels above the dew point during handling operations when they are not submerged in solvent or stored in a desiccator.

(c) Wipe the surfaces clean with solvent soaked rags and scrub with surgical gauze swabs in a beaker of hot naptha.

(d) Rinse in a beaker of hot methanol. Air dry the panels and store in a desiccator until further processing.

4.11.1.3 Sandblasting test panels. The unnumbered side of the test panels shall be sandblasted to a fresh, uniformly abraded surface with clean, white, dry, sharp sand, of a size that will allow all of it to pass through a number 10 sieve, a minimum of 90 percent to pass through a number 20 sieve, and not more than 10 percent to pass through a number 50 sieve. The size designiation of all sieves shall conform to Specification RR-R-366. Immediately after sandblasting, the panels shall be placed into a container of anhydrous

methanol. Remaining residue and contamination shall be removed by holding the panels in a rack at 20° from the vertical and spraying downward with naptha. Flush the test surface, then the back of the panel and the test surface again. The panels shall then be rinsed in hot naptha and hot methanol. After the panels are dry they shall be stored in a desiccator and used the same day as prepared.

4.11.1.4 Test procedure. Three test panels shall have a Cal. .30 primed, (corrosive) empty cartridge case fired at the center of each (see 6.3). The primed case shall be held in a rigid manner at 45° obliquely with a distance of one inch between the cartridge and the test panel. The panels shall then be slushed in approximately 800 ml. of the cleaner under test for 2 minutes. The panels shall then be suspended by stainless steel or monel hooks and exposed in the humidity cabinet specified in Specification JAN-H-792 for 3 days. The slushing of the panels in the test cleaner shall be accomplished mechanically by use of a reciprocal stroking machine such as shown in Figure 1. The panels shall be mounted in the test holder, so that the contaminated side of the panels are in a plane perpendicular to the path of the slushing motion. The length of the stroke shall be 2 ± 1/4 inch and the slushing shall be conducted at 30 ± 1 cycles per minute. After exposure of the panels in the humidity cabinet for 3 days, the panels shall be examined in the significant area of the panels as defined in Specification JAN-H-792. At least two of the panels shall be free of corrosion and the third panel shall have no more than three corrosion dots, none of which exceed one millimeter in diameter. Corrosion in excess of this shall be cause for rejection.

4.11.2 Humidity cabinet.

4.11.2.1 Test panels. Three test panels for the humidity cabinet test shall be of the same size and material as specified in 4.11.1.1, and cleaned and sandblasted as specified in 4.11.1.2 and 4.11.1.3.

4.11.2.2 Test procedure. The test panels shall be dipped in the test cleaner at a temperature of 77 ± 50°F and agitated gently for one minute. The panels shall then be suspended by means of stainless steel or monel hooks and drained for two hours at that temperature. The panels shall be subjected to 7 days of the humidity cabinet test specified in Specification JAN-H-792. At least two of the panels shall be free of corrosion and the third panel shall have no more than three corrosion dots, none of which exceed one millimeter in diameter. Corrosion in excess of this amount shall be cause for rejection.

REFERENCES

1. Bootzin, David, "One Day versus Three Day Cleaning of Cannon Tubes", Report Number 61-3712, Rock Island Arsenal Laboratory, Rock Island, Ill., October 1961.

2. Brodman, Bruce W., Devine, Michael P., "The Effects of Inorganic Propellant Additives on Barrell Fouling and Erosion in 20 MM Systems", Report R-3016, Frankford Arsenal, Philadelphia, PA., June 1974.

3. "Cleaning Compound Solvent For Bore of Small Arms and Automatic Aircraft Weapons, Military Specification MIL-C-372B", November 1963.

4. "Diesel Fuels - SAE J313a", SAE Information Report, Report of the Fuels and Lubricants Techanical Committee, July 1969.

5. "Dry Cleaning Solvent, Federal Specification P-D-680", June 1964.

6. Hicks, Charles R., Fundamental Concepts in the Design of Experiments, Holt, Rinehart and Winston, Inc., 1973.

7. "Hydraulic Fluid, Petroleum Base, For Preservation and Operation, Military Specification MIL-H-6083D", September 1973.

8. "Lubricating Oil, Preservative, Medium, Military Specification MIL-L-3150B", April 1971.

9. "Lubrication, Automatic Transmission Fluids", Vol. 54 Number 1, Published by Texaco Inc., 1968.

10. "Lubrication Order L09-2350-215-12, Tank, Combat, Full Tracked, 105 MM Gun, M60", January 1974.